Earth Entry System Atmosphere Model Study

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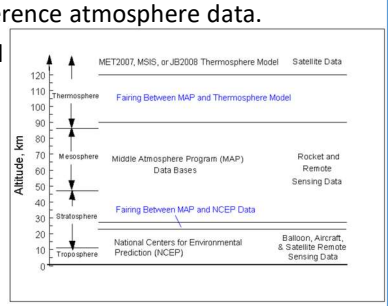
Background

- The Mars Sample Return Campaign has the ambitious goal of returning Mars samples back to Earth [1]. The Earth Entry System (EES), containing the samples, conducts entry, descent, and landing (EDL) on a direct Earth trajectory. During EDL, the EES traverses through many regions of Earth's atmosphere before impacting the ground at Utah Test and Training Range (UTTR).
- This poster highlights preliminary results from a study that assessed the flight mechanics simulation sensitivity to atmosphere model settings and investigated the validity of current atmosphere models as compared to available atmospheric data measurements.

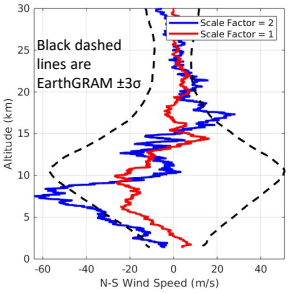
Atmosphere Modeling

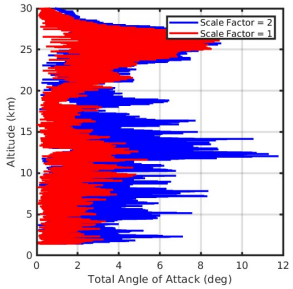
- Earth Global Reference Atmospheric Model (EarthGRAM) 2010 utilized as engineering atmosphere model [2].
- Built upon a variety of historical data sources, including range reference atmosphere data.
- Can simulate spatial and temporal perturbations in atmospheric parameters in Program to Optimize Simulated Trajectories II [5].

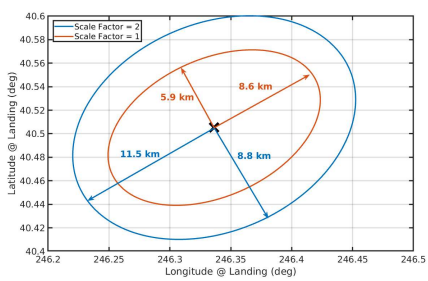


Sensitivity Studies

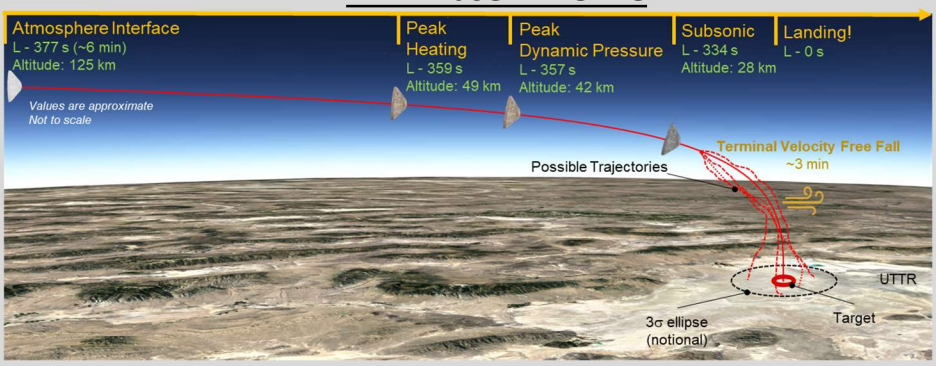
- Ran 20000 Monte Carlo simulations with only modifications to EarthGRAM parameters (e.g. atm perturbation scale factor).
- Assessed flight mechanics quantities of interest (e.g. total angle of attack, landing ellipse).







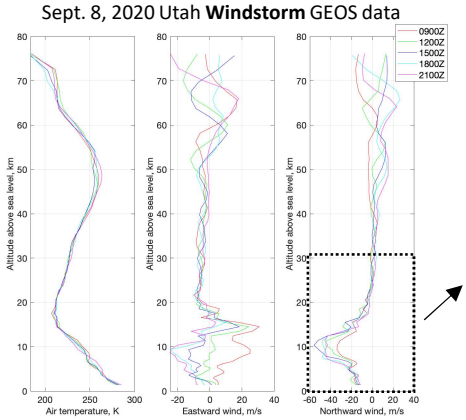
EDL Phase Timeline



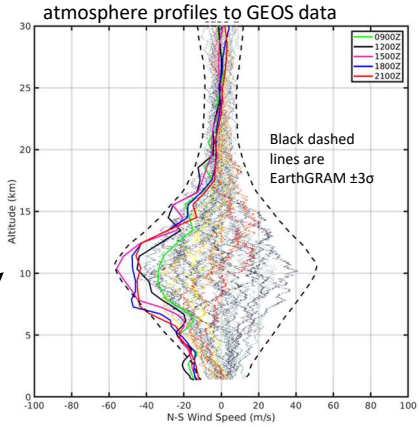
Model Validation

- Stress simulation range of EarthGRAM atmospheric parameters and accuracy of atmospheric perturbations.
- NASA Global Modeling and Assimilation Office Goddard Observing System (GEOS) historical data around UTTR region is utilized [3].

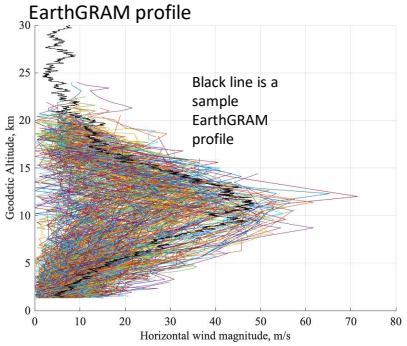
Sept. 8, 2020 Utah **Windstorm** GEOS data



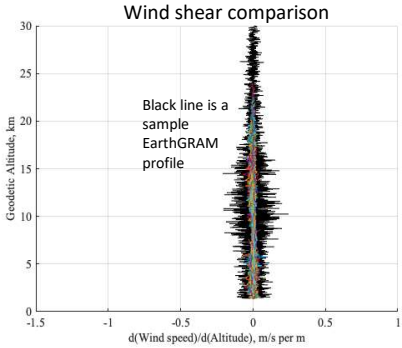
Comparison of simulated EarthGRAM atmosphere profiles to GEOS data



Dugway radiosonde data [4] comparison to EarthGRAM profile



Wind shear comparison



Study Findings

- Preliminary results show EarthGRAM 2010 provides a bounding wind environment for assessment for EES flight mechanics and landing footprint
- EarthGRAM 2010 atmosphere model validated with historical datasets.

References

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2. White, P. and Hoffman, J., "Earth Global Reference Atmospheric Model (Earth-GRAM): User Guide," NASA TM-20210022157.
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4. NOAA National Centers for Environmental Information, "Integrated Global Radiosonde Archive", Version 2, https://www.ncei.noaa.gov/products/weather-balloon/integrated-global-radiosonde-archive
5. Program to Optimize Simulated Trajectories II (POST2): https://www.nasa.gov/post2